Office de la Propriété Intellectuelle du Canada
Un organisme d'Industrie Canada

Canadian Intellectual Property Office
An agency of Industry Canada

CA 2419085 A1 2002/03/28

(21) 2 419 085

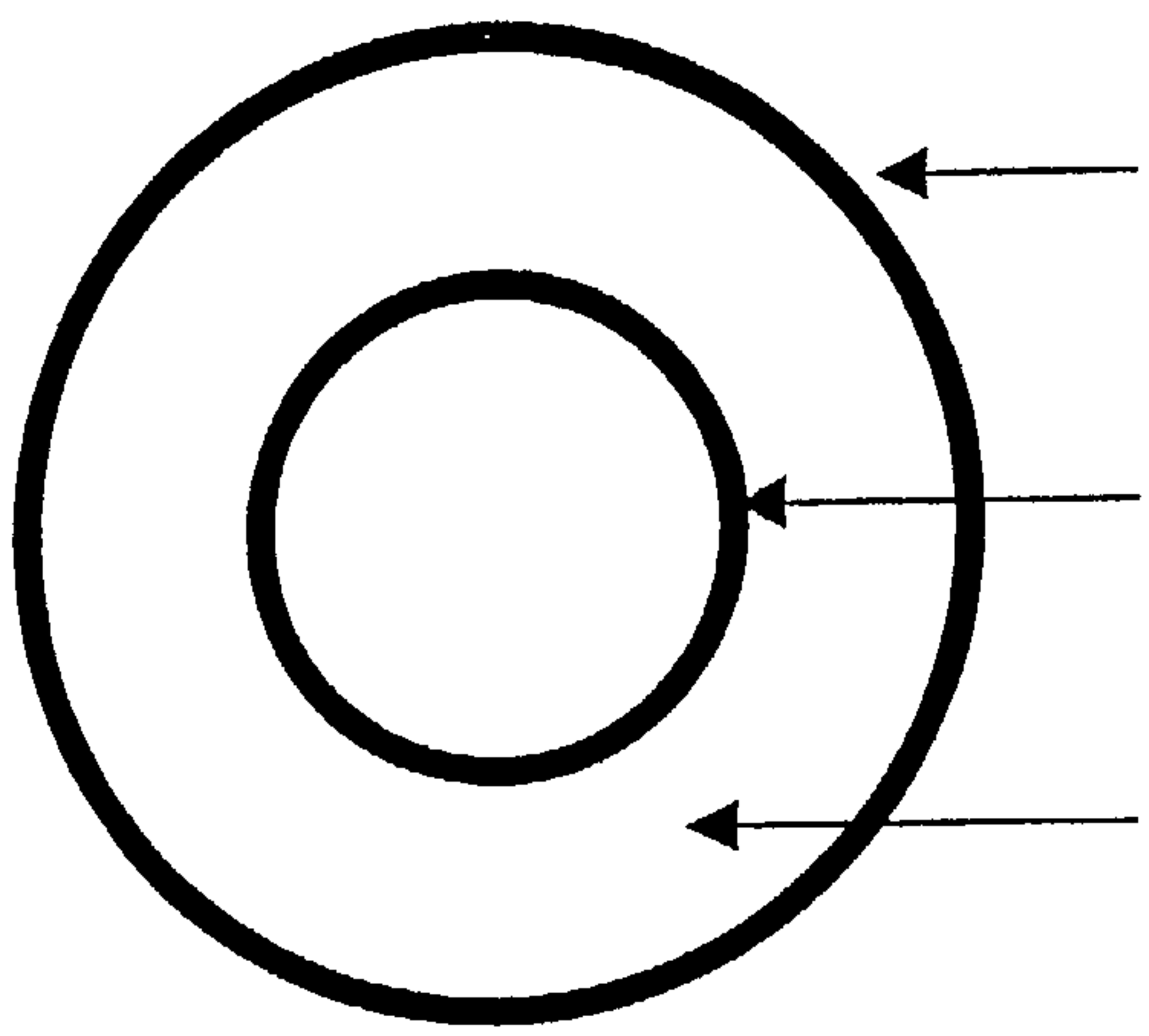
(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(86) Date de dépôt PCT/PCT Filing Date: 2001/09/17
(87) Date publication PCT/PCT Publication Date: 2002/03/28
(85) Entrée phase nationale/National Entry: 2003/02/06
(86) N° demande PCT/PCT Application No.: NO 2001/000378
(87) N° publication PCT/PCT Publication No.: 2002/025160
(30) Priorité/Priority: 2000/09/25 (20004783) NO

(51) Cl.Int.⁷/Int.Cl.⁷ F16L 9/08
(71) Demandeur/Applicant:
AKER RISER SYSTEMS AS, NO
(72) Inventeur/Inventor:
SELE, ARNE, NO
(74) Agent: KIRBY EADES GALE BAKER

(54) Titre : STRUCTURE DE PIPELINES
(54) Title: ARRANGEMENT FOR PIPELINES



(57) Abrégé/Abstract:
Arrangement for deepwater pipelines (2), wherein an internal thick-walled pipeline (6) comprises an outer mantel layer providing buoyancy and/or insulation for said deepwater pipelines (2), said mantel layer comprising lightweight concrete thereby forming a lightweight concrete mantel layer (5), said lightweight mantel layer (5) being covered by an external thin walled tube or skin (7), said external thin walled tube or skin (7) reinforcing said lightweight concrete mantel layer (5) and keeping said lightweight concrete mantel layer (5) dry.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
28 March 2002 (28.03.2002)

PCT

(10) International Publication Number
WO 02/25160 A1

(51) International Patent Classification[7]: F16L 9/08

(21) International Application Number: PCT/NO01/00378

(22) International Filing Date:
17 September 2001 (17.09.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
20004783 25 September 2000 (25.09.2000) NO

(71) Applicant *(for all designated States except US)*: **AKER RISER SYSTEMS AS** [NO/NO]; Postboks 246, Lilleaker, N-0216 Oslo (NO).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **SELE, Arne** [NO/NO]; Haresvingen 10, N-1352 Hosle (NO).

(74) Agent: **OSLO PATENTKONTOR AS**; Postboks 7007 M, N-0306 Oslo (NO).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AT (utility model), AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, CZ (utility model), DE, DE (utility model), DK, DK (utility model), DM, DZ, EC, EE, EE (utility model), ES, FI, FI (utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (utility model), SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

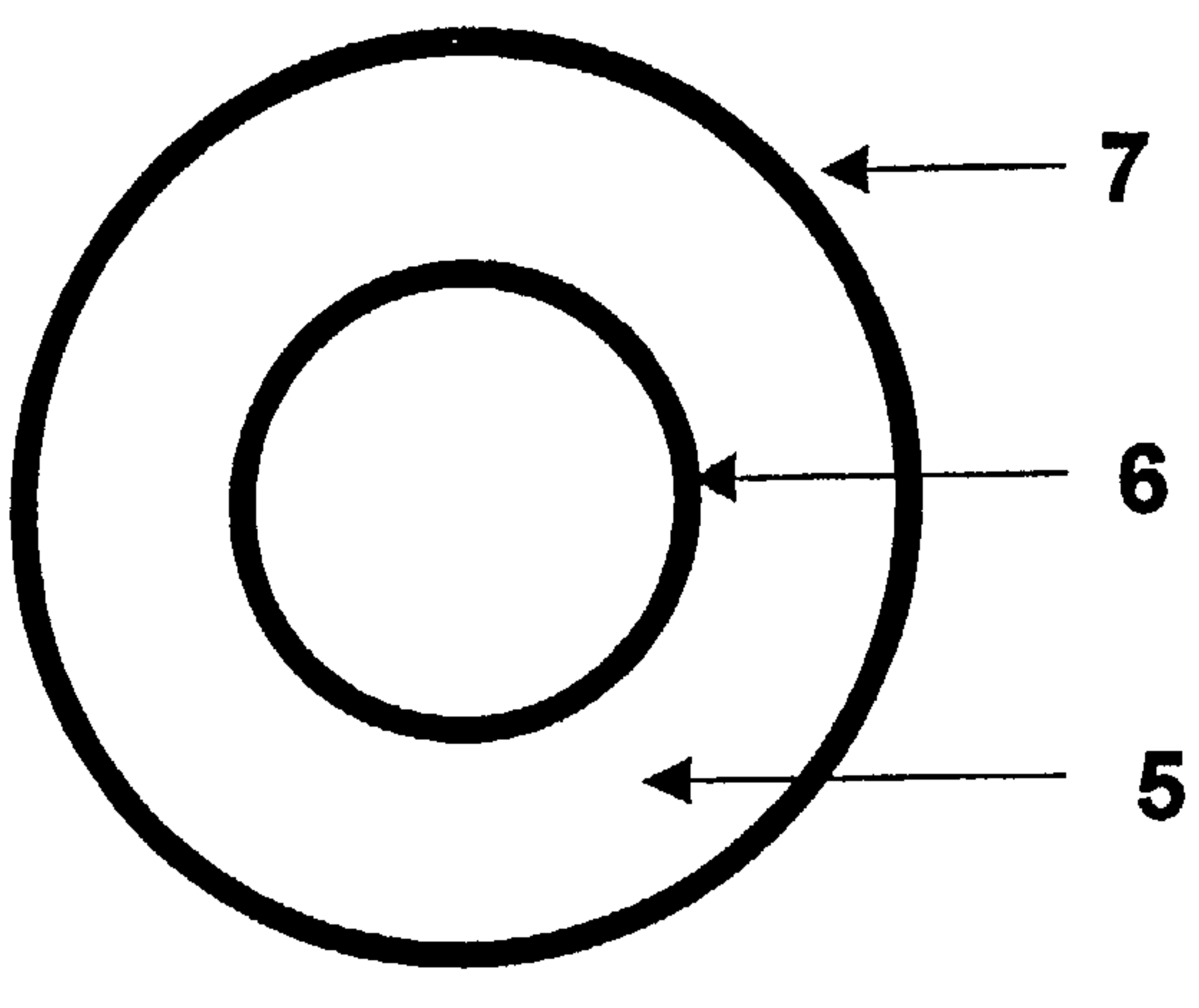
(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:
— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii)) for the following designations AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)*
— *of inventorship (Rule 4.17(iv)) for US only*

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: ARRANGEMENT FOR PIPELINES



(57) Abstract: Arrangement for deepwater pipelines (2), wherein an internal thick-walled pipeline (6) comprises an outer mantel layer providing buoyancy and/or insulation for said deepwater pipelines (2), said mantel layer comprising lightweight concrete thereby forming a lightweight concrete mantel layer (5), said lightweight mantel layer (5) being covered by an external thin walled tube or skin (7), said external thin walled tube or skin (7) reinforcing said lightweight concrete mantel layer (5) and keeping said lightweight concrete mantel layer (5) dry.

WO 02/25160 A1

ARRANGEMENT FOR PIPELINES

The present invention relates to deepwater pipelines.

Pipe-laying barges of the S-lay and J-lay type that are currently available have sufficient tensioner capacity to lay down pipelines at great depths down to about 1000 to 2000 meters. The specific depth depends to a great extent on the diameter, wall thickness and weight of the pipeline that is to be laid. In order to increase the maximum depth at which today's conventional equipment is able to lay pipelines, it is necessary to reduce weight, add buoyancy or both. The alternative is to increase vessel sizes and tensioner capacity, but this is not considered commercially viable.

Another aspect of deepwater production is the high pressure differential between the surface and the seabed. The hydrostatic pressure exerted on the production fluid at this depth may under some circumstances contribute to the formation of hydrates. This makes hydrate formation a far greater challenge than at more normal depths. Since the formation of hydrates depends on pressure and temperature, the detrimental effect of the increased pressure may be offset by supplementary thermal insulation. Presently, different kinds of insulation materials are in use, i.e. insulating syntactic foam or rubber, for pipelines at great depths. However, these materials have so far proven to be expensive.

The use of lightweight concrete has previously been described in US patent no 4 393 901. Here the lightweight concrete, which by nature is porous, is provided as a surface layer directly exposed to the surrounding seawater. Water is gradually absorbed and as a consequence buoyancy and thermal insulation will be lost as water is absorbed. The depth at which this can be used will be limited to the concrete's uni-axial compressive strength and the capacity of the pipe to support external water pressure without buckling or imploding. This design derives no significant strength from the surrounding concrete.

The use of pipe-in-pipe designs where the annulus between the pipes is filled with insulating materials such as mineral fibers is well known in the industry. Norwegian patent no 304662 and UK patent 2 271 410 describes the use of micro-spheres which as a solid will provide strength and restrain the external pipe from collapsing under external pressure. Such particles (micro-spheres) will have pointwise contact and high stress will be set up in these contact points. This will severely limit the compressive strength of the micro-spheres and the external hydrostatic pressure which can be supported. The injection of epoxy or cement based adhesive bonding agents to improve shear strength is also described. This will, however, not have significant impact on compressive strength as the micro-spheres will still make point contact through the much softer adhesive. The capacity of this pipe to sustain external pressure will not be significantly different from the pipe on its own.

It is the aim of the present invention to provide a deepwater pipeline that solves the two aforementioned problems in a cheap and reliable manner, which does not require modifications of existing pipe-laying equipment or special auxiliary pipe-laying equipment. The characterizing features of the invention are given in claim 1. Preferable features and embodiments are given in the dependent claims.

The present invention is described in reference to the attached drawings, of which:

Fig. 1 shows a general overview of one possible pipe-laying technique, and

Fig. 2 shows a schematic section of a preferred embodiment according to the invention.

Fig. 1 shows a general overview of a pipe-laying technique of the S-lay type. The free-span portion 1 of the pipeline 2 has to be carried by the pipe-laying barge 3. In order to prevent excessive sagging of the free-span portion 1, the pipeline is held in tension by the barge 3. The deeper the seabed, the heavier the load is on the barge 3 and tension equipment. The tension is exerted by tension equipment on board of the barge and is mainly dependent on friction forces between the tension equipment and the pipeline 2. Obviously, the pipeline 2 may be exposed to such high clamping forces that it may be crushed and/or damaged.

Fig. 2 shows a schematic view of one embodiment according to the present invention. The applicant has found that a lightweight concrete mantel layer 5 around the internal thick walled pipeline 6 may provide both buoyancy and insulation to a pipeline 2 that is to be laid down in great water depths.

As noted lightweight concrete has a modest strength. According to the present invention it is provided with an external thin-walled tube or skin 7, preferably of metal but possibly of any other suitable material, which reinforces the lightweight concrete mantel layer 5 against the pressure applied from the tensioning equipment and hydrostatic pressure. Such tri-axial confinement causes a two to three-fold increases of the compressive stress that can be sustained. The invention also includes the use of high strength concrete technology pioneered in Norway. The technology of producing high strength concrete involves the use of very carefully graded particles which pack together in such a way that contact stresses between particles become very uniform. This gives a several-fold increase of compressive strength.

For deepwater applications the external hydrostatic pressure which can be supported is a primary consideration. Sufficient compressive strength of the concrete is one important feature. The second aspect is to prevent the unstable collapse of the pipe under external pressure. The high strength lightweight concrete according to this invention will develop extensive composite action between the two pipes, which will vastly increase the collapse strength. This makes it possible to reduce the wall thickness of the steel pipeline itself considerably.

As also noted, lightweight concrete also tends to absorb water. In order to achieve the most favorable heat conductivity rates, it needs to be kept dry. The external thin-walled tube or skin 7 therefore also prevents moisture from penetrating into the concrete mantel layer 5 and thereby contributes to the insulating capability of the concrete mantel layer 5. Finally, the external thin walled tube or skin 7 may act as formwork for casting of the concrete mantel layer 5. In one embodiment, the internal thick walled pipeline 6 is centrally positioned within the external thin walled tube or skin 7, whereupon lightweight concrete is poured into the annulus formed between the internal thick walled pipeline and the external thin walled tube or skin 5. The lightweight concrete mantel layer 5 is thereafter allowed to settle and cure. The ends of the annulus may finally be covered by suitable, annually shaped covers or by other suitable means.

In summary it is seen that high strength lightweight concrete with a confining carrier pipe gives the following significant advantages:

- The lightweight aggregate concrete provides permanent buoyancy and insulation.
- The external carrier pipe is supported by the concrete which has a tenfold greater compressive strength than the aggregate would have as particles with or without a

cement past or other form of adhesive coating. This makes it possible to use a very thin walled carrier pipe.

- The external carrier pipe prevents ingress of water that otherwise would reduce the buoyancy and increase the thermal conductivity of the concrete.
- The composite action of the concrete and the two steel pipes increases the crushing strength of concrete through confinement. It also dramatically increases the external pressure that can be sustained by the pipeline without buckling, as for deep-water applications buckling of the pipe under external hydrostatic pressure will determine wall thickness. This reduces the total amount of steel required in deepwater applications.

Non-limiting examples of suitable, lightweight concrete for enhancement according to the present invention are given in the following table:

Table 1

Lightweight concrete type	Dry density Kg/l	Heat conductivity W/m°K
Exfoliated vermiculite	0.40-0.80	0.11-0.22
Air entrained cement	0.35-0.80	0.10-0.20
Foamed slag	0.65-1.00	0.12-0.50
Pumice	0.70-1.00	0.22-0.33

Pipe-laying with concrete weight coating is a well-established technique. The techniques used according to the present invention will include many of the same elements, but the technical challenges will differ. Developing sufficient strength of the external thin walled tube or skin 7 in combination with the sufficient crushing strength of the concrete mantel layer 5 must be balanced against obtaining the desired heat conductivity or density. It is envisaged that double joints with lightweight concrete surrounded by an outer steel tube or skin 7 will be supplied to a conventional lay barge from an onshore facility. Field jointing techniques will be similar to weight coated pipelines.

C l a i m s

1. Arrangement for deepwater pipelines (2), wherein an internal thick-walled pipeline (6) comprises an outer lightweight concrete mantel layer (5) providing buoyancy and/or insulation for said deepwater pipelines (2), c h a r a c t e r i z e d i n the outer mantel layer (5) comprises an external thin-walled tube or skin (7) which reinforces said lightweight concrete mantel layer (5) against the pressure applied from the tensioning equipment and hydrostatic pressure and keeps said lightweight concrete mantel layer (5) dry, said outer lightweight concrete mantel layer (5) being made up of carefully graded particles which pack together in such a way that contact stresses between particles become very uniform.

2. Arrangement according to claim 1, c h a r a c t e r i z e d i n that said lightweight concrete mantel layer (5) comprises exfoliated vermiculite and/or air entrained cement and/or foamed slag and/or pumice and/or any other lightweight concrete with a dry density under 1.00 kg/l and/or a heat conductivity under 0.50 W/m°K.

3. Arrangement according to claim 1 or 2, c h a r a c t e r i s e d i n that said lightweight concrete is enhanced by high strength concrete technology, tri-axial confinement and composite action to make the pipe-in-pipe configuration sustain the external pressure of ultra deepwater applications.

3. Arrangement according to claim 1, c h a r a c t e r i z e d i n that said external thin walled tube or skin (7) is made of steel.

4. Arrangement according to claim 1, c h a r a c t e r i z e d i n that said external thin walled tube or skin (7) is made of any other suitable material.

5. Arrangement according to any of the previous claims, c h a r a c t e r i z e d i n that heating means are provided within said lightweight concrete mantel layer (5).

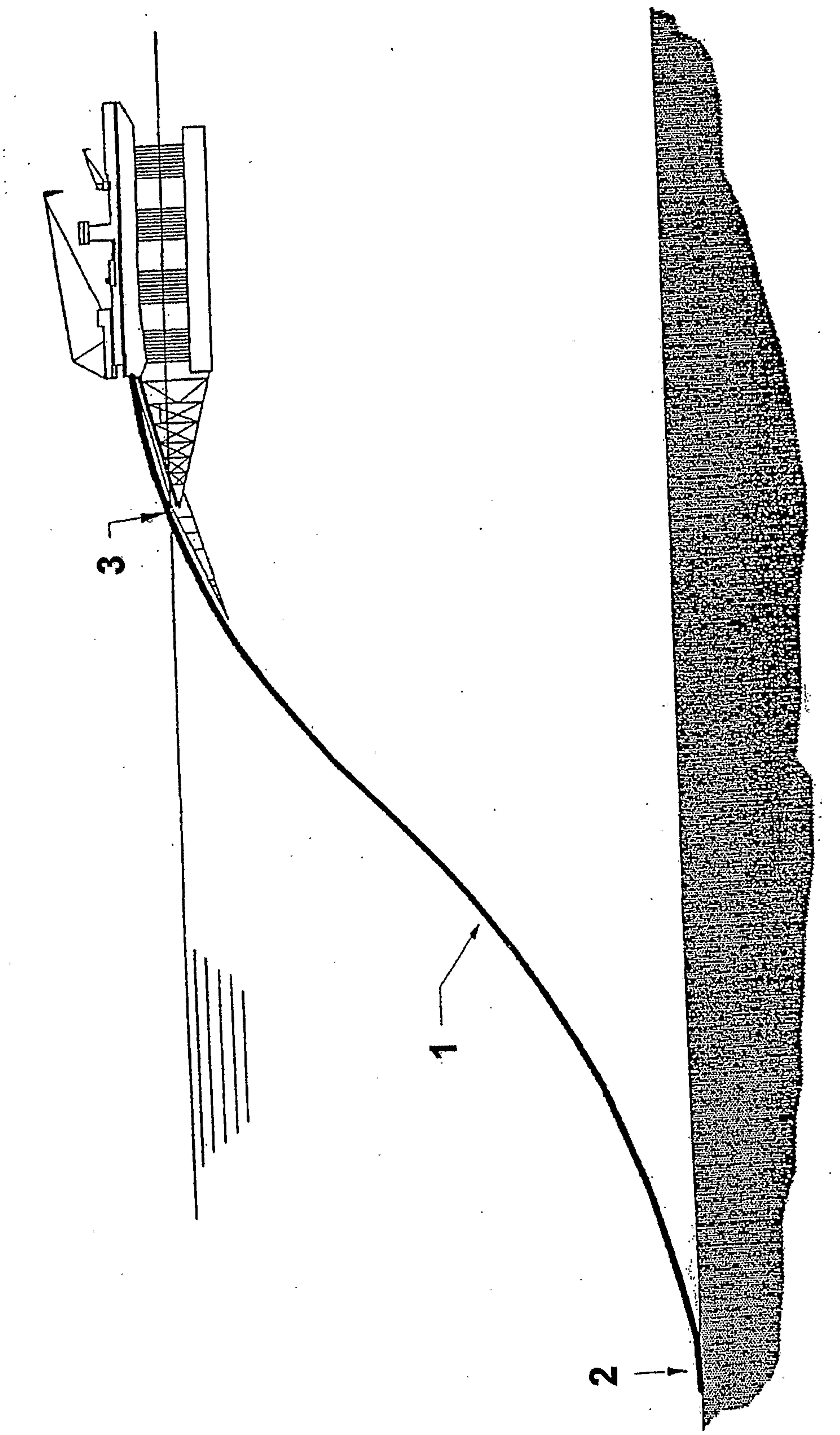


Fig. 1

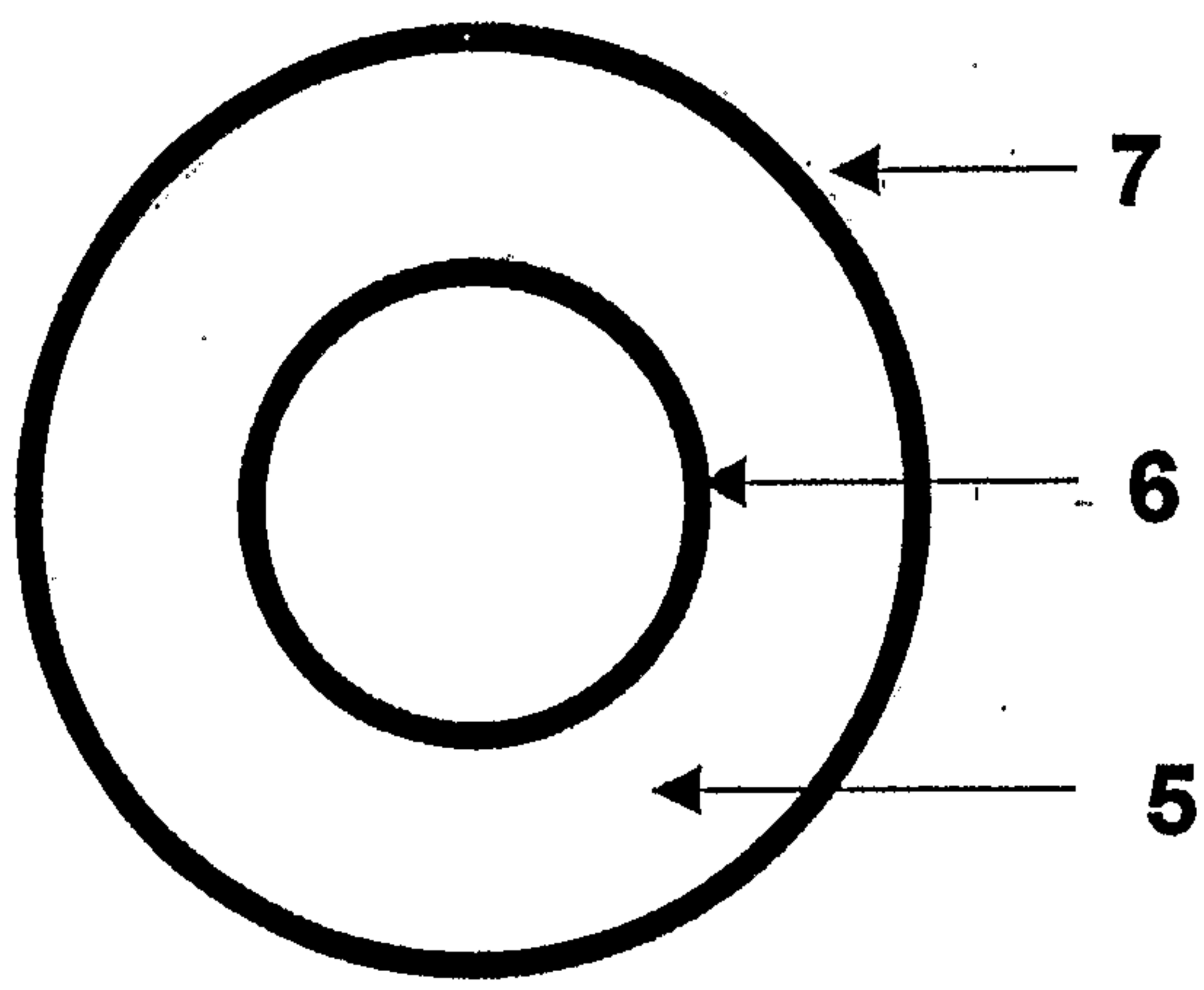
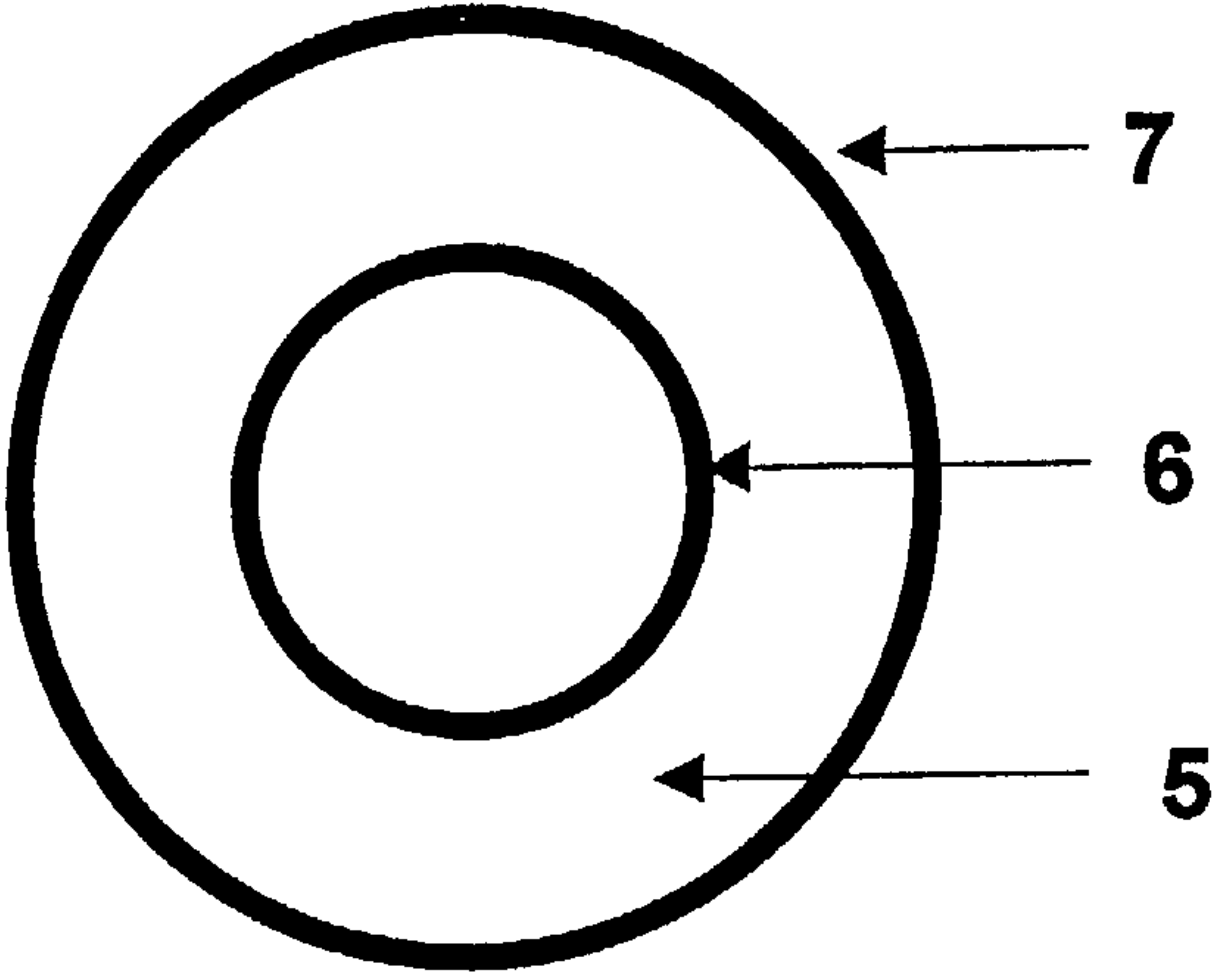


Fig. 2


7
6
5